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Correlation and path analysis for seed yield and its components traits in ajwain (*Trachyspermum ammi* L.)

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Abstract
Correlation and path analysis establish the extent of association between yield and its components and also bring out the relative importance of their direct and indirect effects and thus, give a clear understanding of their association with seed yield. The experimental materials consisted of 30 diverse germplasm lines for character association ship study among characters revealed that seed yield per plant was positively and significantly correlated with number of umbel per plant, weight of grains per umbel, plant height and 1000 seed weight. Path coefficient analysis revealed that weight of grains per umbel, number of umbels per plant, plant height, days to maturity and 1000 seed weight had maximum positive direct effect on seed yield per plant. Consequently, simultaneous improvement of these traits by selection will improve seed yield of ajwain.

Keywords: *Trachyspermum ammi* L., correlation coefficient, path analysis

Introduction
Ajwain, *Trachyspermum ammi* L. belonging to family Apiaceae is a highly valued medicinally important seed spice. It is a native of Egypt and is cultivated in Iraq, Iran, Afghanistan, Pakistan, and India. In India, it is cultivated in Madhya Pardesh, Uttar Pardesh, Gujarat, Rajasthan, Maharashtra, Bihar and West Bengal (Anonymous, 2011) [2]. The total area and production of ajwain in India are about 0.024 Mha and 0.014 Mt, respectively with 0.58 tonnes per hectare productivity (Anonymous, 2016-17) [3]. The fruit possesses stimulant, antispasmodic and carminative properties and is used traditionally as an important remedial agent for flatulence, atonic dyspepsia, diarrhea, abdominal tumors, abdominal pains, piles, and bronchial problems, lack of appetite, Galactogogue, asthma and amenorrhoea (Zarshenas *et al*., 2014) [14]. Production of a stable quality and quantity of these plants is important to growing world market, which make it necessary to breed varieties with high yield and quality. Seed yield is a quantitative trait and highly exaggerated by environmental factors (Poormohammad *et al*., 2009) [11]. Correlation of a particular character with other characters contributing to seed yield is of great importance in indirect selection of genotypes for higher seed yield (Ali *et al*., 2003; Subramaniyan *et al*., 2018) [1, 12]. Path coefficient analysis is a statistical technique of partitioning the correlation coefficients into its direct and indirect effects, so that the contribution of each character to yield could be estimated (Dewey and Lu, 1959) [5]. Path coefficient analysis have been widely used in plant breeding programs to determine the nature of the relationships between yield and yield components that are useful as selection criteria to improve crop yield. In most studies involving path analysis, researchers considered the predictor characters as first-order variables in order to analyze their effects over a dependent variable such as yield (Ghanshyam *et al*., 2015; Meena *et al*., 2017; Faravani *et al*., 2018) [8, 10, 7]. The objective of present study was to determine the interrelationships among yield and related characteristics in ajwain for developing selection criteria for improving seed yield.

Materials and Methods
Thirty diverse genotypes of ajwain was laid in Randomized Block Design with three replications during *Rabi* season, 2014-15 at Main Experiment Station (Vegetable Research Farm), Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad, India (26.47° North latitude and 82.12° East longitudes at an altitude of 113 m above the mean sea level). The plot size was of 0.6 m × 1.80 m with row to row spacing of 45 cm and plant to plant spacing of 20 cm. All the recommended package of practices was followed to raise a healthy crop. The observations were recorded on five randomly selected plants from each

genotype in each replication for the characters *viz*., plant height (cm), number of branches per plant, number of umbels per plant, number of umbellates per umbel, weight of grains per umbel (g), 1000 seed weight (g) and seed yield per plant (g), while for germination (%), days to 50% flowering and days to maturity, the data were recorded as whole plot basis. Genotypic and phenotypic correlation coefficients for all the possible comparisons were computed as per Johnson *et al*. (1955) [9]. The partitioning of genotypic correlation coefficient of traits into direct and indirect effects was carried out as per suggested by Dewey and Lu (1959) [5].

Results and Discussion

Correlation coefficient

The statistics that measures the association between two or more variables is known as correlation coefficient. It measures the mutual relationship between various plant characters and determines component characters on which selection can be based for improvement in seed yield. It might be easier to increase seed yield by increasing the smallest yield components on an otherwise good cultivar. The genotypic and phenotypic correlations were presented in Table 1. Significance has been tested with a view to their linearity in association. In general, the genotypic correlations were higher than the phenotypic ones, which indicated that the phenotypic expression of the correlation is reduced under the influence of environment (Falconer, 1988) [6], although there is a strong inherent association between the various characters.

In the present investigation, significant and positive correlation with seed yield per plant was exhibited at phenotypic level by number of umbel per plant (0.277), weight of grains per umbel (0.370), plant height (0.274) and 1000 seed weight (0.221), whereas significant and negative correlation observed by number of branches per plant (-0.260) (Table 1). On the other hand, significant and positive correlation with number of umbels per plant and plant height was recorded at phenotypic level by germination percentage (0.323 and 0.315, respectively). However, weight of grains per umbel showed significant and negative correlation with number of umbellets per umbel (-0.207). Days to maturity observed with significant and negative correlation by days to 50% flowering (-0.374). Though, the significant negative and positive correlation was recorded by days to 50% flowering (-0.211) and days to maturity (0.258), respectively with 1000 seed weight at phenotypic level. The results suggested that these traits can be utilized as selection indices for yield improvement in ajwain. Similar findings was also revealed by the previous workers *viz*., Dalkani *et al*. (2011) [4], Ghanshyam *et al*. (2015) [8], Meena *et al*. (2017) [10], Faravani *et al*. (2018) [7] and Subramaniyan *et al*. (2018) [12] in ajwain.

Table 1: Estimates of genotypic and phenotypic correlation coefficient among different characters of Azwain genotypes

Characters	**Correlation coefficient**	**Days to 50% flowering**	**Number of branches per plant**	**Number of umbels per plant**	**Number of umbellets per umbel**	**Weight of grains per umbel**	**Plant height (cm)**	**Days to maturity**	**1000 seed weight (g)**	**Seed yield per plant (g)**
Germination %	rg	0.159	0.190	0.702	0.184	-0.256	0.606	-0.090	-0.239	0.044
	rp	0.098	0.121	0.323**	0.142	-0.120	0.315**	-0.104	-0.171	0.047
Days to 50% flowering	rg		-0.166	0.488	-0.127	-0.305	0.211	-0.699	-0.331	0.284
	rp		-0.057	-0.034	-0.077	-0.078	0.014	-0.374**	-0.211*	0.107
Number of branches per plant	rg			0.392	0.012	0.007	-0.219	-0.051	-0.082	-0.259
	rp			0.076	0.019	0.040	-0.128	-0.049	-0.071	-0.260**
Number of umbels per plant	rg				0.060	-0.293	-0.049	-0.194	-0.280	0.393
	rp				-0.025	-0.078	-0.036	-0.073	-0.043	0.277**
Number of umbellets per umbel	rg					-0.295	0.150	0.128	-0.204	-0.149
	rp					-0.207*	0.126	0.100	-0.206	-0.147
Weight of grains per umbel	rg						-0.122	0.007	-0.153	0.452
	rp						-0.125	-0.021	-0.115	0.370**
Plant height (cm)	rg							-0.039	-0.270	0.291
	rp							-0.011	-0.204	0.274**
Days to maturity	rg								0.290	0.145
	rp								0.258*	0.130
1000 seed weight (g)	rg									0.247
	rp									0.221*

*, ** significant at $P< 0.05$ or $P< 0.01$, respectively.
rg= Genotypic correlation
rp= Phenotypic correlation

Path analysis

The concept of path coefficient analysis was originally developed by Wright (1921) [13], but the technique was first used for plant selection by Dewey and Lu (1959) [5]. Path analysis is simply standardized partials regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects of a set of independent variables on the dependent variable. Phenotypic correlations of the characters were partitioned to path coefficient with a view to identify important component characters having direct effects on seed yield. The direct and indirect effect of different characters on seed yield per plant at phenotypic level is presented in Table 2. Highest positive direct effect on seed yield per plant was registered by weight of grains per umbel (0.335), number of umbels per plant (0.204), plant height (0.181), days to maturity (0.164) and 1000 seed weight (0.158) had positive, direct, effects (Table 2), likely due to the positive association with seed yield per plant. Direct effects of other characters were negligible. Direct selection could be beneficial for yield improvement since weight of grains per umbel, number of umbels per plant and 1000 seed weight exhibited significant, positive, correlations with seed yield per plant. High positive, direct, effects of weight of grains per umbel, number of umbels per plant and 1000 seed weight on seed yield per plant were obtained with other genotypes and environmental conditions by others like Ghanshyam *et al*.

(2015) [8], Meena *et al*. (2017) [10], Faravani *et al*. (2018) [7] and Subramaniyan *et al*. (2018) [12] in ajwain. Residual effect of the path analysis was low (0.65) suggesting the inclusion of maximum seed yield influencing characters in the present study.

Table 2: Genotypic and phenotypic path analysis for different characters of Azwain genotypes.

Characters		Germination %	Days to 50% flowering	Number of branches per plant	Number of umbels per plant	Number of umbellets per umbel	Weight of grains per umbel	Plant height (cm)	Days to maturity	1000 seed weight (g)	Correlation with Seed yield per plant (g)
Germination %	G	6.701[a]	0.806	0.190	-4.470	0.008	-0.082	-2.894	-0.268	0.053	0.044
	P	-0.035	0.015	-0.025	0.066	-0.028	0.040	0.057	-0.017	-0.027	0.047
Days to 50% flowering	G	1.069	5.054	-0.178	-2.537	-0.005	-0.098	-1.006	-2.091	0.077	0.284
	P	-0.003	0.157	0.012	-0.007	0.015	0.026	0.003	-0.061	-0.033	0.107
Number of branches per plant	G	1.220	-0.862	1.042	-2.623	0.000	0.003	1.098	-0.158	0.019	-0.259
	P	-0.004	-0.009	-0.203	0.016	-0.004	-0.013	-0.023	-0.008	-0.011	-0.260**
Number of umbels per plant	G	4.711	2.017	0.430	6.358	0.003	-0.094	0.195	-0.574	0.061	0.393
	P	-0.011	-0.005	-0.015	0.204	0.005	0.026	-0.007	-0.012	-0.007	0.277**
Number of umbellets per umbel	G	1.236	-0.644	0.011	-0.411	0.041	-0.095	-0.715	0.384	0.043	-0.149
	P	-0.005	-0.012	-0.004	-0.005	-0.198	0.070	0.023	0.016	-0.032	-0.147
Weight of grains per umbel	G	-1.716	-1.544	0.010	1.852	-0.012	0.322	0.580	0.022	0.035	0.452
	P	0.004	-0.012	-0.008	-0.016	0.041	0.335	-0.023	-0.003	-0.018	0.370**
Plant height (cm)	G	4.063	1.065	-0.240	0.260	0.006	-0.039	-4.772	-0.115	0.063	0.291
	P	-0.011	0.002	0.026	-0.007	-0.025	0.042	0.181	-0.002	-0.032	0.274**
Days to maturity	G	-0.600	-3.535	-0.055	1.219	0.005	0.002	0.184	2.990	-0.066	0.145
	P	0.004	-0.059	0.010	-0.015	-0.020	0.007	-0.002	0.164	0.041	0.130
1000 seed weight (g)	G	-1.578	-1.719	-0.088	1.703	-0.008	-0.049	1.332	0.877	0.227	0.247
	P	0.006	-0.033	0.014	-0.009	0.041	0.039	-0.037	0.042	0.158	0.221*

*, ** significant at $P< 0.05$ or $P< 0.01$, respectively.
[a]Diagonal bold figures represent direct effects; Residual effect (RG) = 1.189; Residual effect (RP) = 0.655
G= Genotypic; P= Phenotypic

Conclusion

From the study of character association ships, combining correlation and path coefficient, the characters namely, weight of grains per umbel, number of umbels per plant and 1000 seed weight were the most important selection criteria as they exerted high positive direct effects on seed yield per plant. Therefore, simultaneous improvement of this trait by selection will improve seed yield.

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